Ethylene Oxide/Terumo BCT Air Sampling Study Pre- and Post-Control Air Monitoring Report November 2018

COLORADO
Air Pollution Control Division
Department of Public Health & Environment

I. Summary

In response to the 2014 National Air Toxic Assessment report that used modeling of air emissions data to indicate potential increased cancer risk from ethylene oxide (CAS #75-21-8) in the area surrounding the Terumo BCT sterilization facility in Lakewood, Colorado, the Colorado Department of Public Health and Environment (CDPHE) developed a plan to address concerns in the area. As part of the plan, the CDPHE measured ethylene oxide levels in the air at a number of locations both near to and distant from the Terumo BCT facility. This air monitoring was conducted both before and after additional controls were installed by Terumo BCT to reduce ethylene oxide emissions. This report summarizes the results of these air sampling efforts.

II. Background

On August 22, 2018, The U.S Environmental Protection Agency (EPA) released the 2014 National Air Toxics Assessment (NATA, www.epa.gov/national-air-toxics-assessment). One census tract in Lakewood, Colorado, was noted to have a cancer risk of 498 in a million due to ethylene oxide. The previous NATA, 2011, indicated a cancer risk of less than 5 in a million. A map from the 2014 NATA is provided in Figure 1. The increased risk was associated with a single facility in the census tract. Ethylene oxide is used by Terumo BCT to sterilize the medical equipment that it manufactures. It was determined that while Terumo BCT has not changed their process or emissions, and is well under their permitted level of emissions, EPA significantly reduced the cancer risk threshold level for ethylene oxide in December 2016. A map of ethylene oxide sources listed in EPA's 2014 National Emissions Inventory (NEI) is presented in Figure 2, and a listing of all the sources in Table 1.

Based on this 2014 NATA, a decision was made by the CDPHE to perform a special ambient air monitoring study for ethylene oxide in the vicinity of the Terumo BCT facility (11308 W. Collins Ave., Lakewood, CO) to determine general concentrations in the area. Sampling was performed by the CDPHE Air Pollution Control Division (APCD) for seven consecutive days, commencing on 8/24/2018 at approximately 7:00 a.m. (MDT) and ending on 8/31/2018 at approximately 7:00 a.m. (MDT) using whole-air Summa passivated stainless steel canisters with orifice flow controlled inlets. Canisters were installed by the APCD and sampled for approximately 24-hours before being replaced. Sampling was performed at four locations within the Lakewood Gulch drainage, two to the west of the Terumo BCT sterilization facility and two to the east, at different distances. Figure 3 provides a map of the air sampling locations and Table 2 provides additional details of the sampling locations. Figures 11 through 14 provide a photograph of each site, with the canister.

In addition, based on the initial air sampling results, two background samples were taken on 9/9/2018 – 9/10/2018 for 24-hours using the Summa canisters at existing APCD air monitoring sites, NREL and LaCasa. Both of these locations are outside of census tracts that have elevated risks in the 2014 NATA. Figure 4 provides a map of the background air sampling locations and Table 3 provides additional details

of the background locations. Figures 20 and 22 provide photographs of the two background sites, with the canisters.

Up to this point in time, The Terumo BCT sterilization facility had three emissions point sources, one of which was uncontrolled. This uncontrolled point source was not required to be controlled, per Federal MACT requirements. Following this sampling, Terumo BCT modified their emissions controls so that the uncontrolled source was routed to an existing control system.

With all point sources at the Terumo BCT facility now controlled, CDPHE decided to perform additional ambient air sampling to determine the effectiveness of the emissions controls. As in the pre-control study, post-control sampling was performed for seven consecutive days, commencing on 10/17/2018 at approximately 7:00 a.m. (MST) and ending on 10/24/2018 at approximately 7:00 a.m. (MST) using whole-air Summa passivated stainless steel canisters orifice flow controlled inlets. Canisters were installed by the APCD and sampled for approximately 24-hours before being replaced. Sampling was performed at eight locations within the Lakewood Gulch drainage area, three to the west of the Terumo BCT sterilization facility and five to the east, at different distances. Four of these locations were the same as those used in the pre-control sampling study. The additional four sites focused on areas further away and more in surrounding residential neighborhoods. Figure 3 provides a map of the air sampling locations and Table 2 provides additional details of the sampling locations. Figures 11 through 18 provide a photograph of each site, with the canister.

To assist with selecting the additional sites for the post-control sampling, the APCD performed dispersion modeling using AERMOD based on air pollution emission notice (APEN)-reported pre-control emissions and also for estimated post-control emissions (assuming 99% control for the uncontrolled source). Meteorological data from the APCD's Welch site were deemed to be representative and were used for the modeling. These meteorological data had been used previously for other modeling and were already processed in AERMET. Graphical results of these modeling efforts for 2006 are presented in Figures 5 and 6. Actual post-control emissions modeling will be performed at a later date upon receipt of new stack test emissions information.

In addition, 16 post-control background samples were taken at four existing APCD air monitoring sites, Welch, NREL, Arvada and LaCasa. All of these locations are outside of census tracts that have elevated risks in the 2014 NATA. Background sampling was performed for four consecutive days, commencing on 10/26/2018 at approximately 7:00 a.m. (MST) and ending on 10/30/2018 at approximately 7:00 a.m. (MST). As with the facility area sampling, whole-air Summa passivated stainless steel canisters were installed by the APCD and sampled for approximately 24-hours before being replaced. Figure 4 provides a map of the background air sampling locations and Table 3 provides additional details of the background locations. Figures 19 through 22 provide a photograph of each background site, with the canister.

III. Air Sampling Results

All laboratory analyses were performed by Eastern Research Group (ERG) in Morrisville, NC. ERG also supplied the canisters and sampling inlets for the study. ERG is used by the U.S. Environmental Protection Agency (EPA) as a national contract laboratory for the air toxics studies and has developed methods for recent ethylene oxide sampling projects performed by EPA. Ethylene oxide is analyzed using gas chromatography/mass spectrometry following EPA method TO-15 protocols.

For the pre-control monitoring, the highest 24-hour concentration was 3.570 parts per billion (ppb), or 6.432 micrograms per cubic meter ($\mu g/m^3$), from the sample commencing on 8/24/2018 at Site #2. This is the closest site to the Terumo BCT sterilization facility to the west. The lowest pre-control 24-hour concentration was 0.170 ppb (0.306 $\mu g/m^3$) from the sample commencing on 8/27/2018 at Site #1. Overall, Site #3 on the east side of the Terumo BCT facility had the highest pre-control average concentration over the 7 days of sampling at 1.716 ppb (3.092 $\mu g/m^3$), followed closely by Site #2 on the west side at 1.663 ppb (2.996 $\mu g/m^3$). Site #1 had the lowest pre-control average concentration, at 0.471 ppb (0.848 $\mu g/m^3$), with site #4 a little higher at 0.716 ppb (1.289 $\mu g/m^3$). Table 4 provides a full listing of the pre-control sampling results. Figure 7 provides a chart of the pre-control sampling data, organized by site.

For the two pre-control background samples, one, at the APCD's NREL site had a concentration that was below the laboratory minimum detection level of 0.0453 ppb (0.0816 $\mu g/m^3$). The other, at the APCD's La Casa site had a concentration of 0.167 ppb (0.301 $\mu g/m^3$), which is just below the lowest 24-hour concentration detected at the study sites. Table 5 provides a listing of the pre-control sampling results.

For the post-control monitoring, the highest 24-hour concentration was 1.120 ppb (2.018 $\mu g/m^3$) from the sample commencing on 10/18/2018 at Site #3. This site is located on the east side of the Terumo BCT sterilization facility. The lowest post-control 24-hour concentration was below the laboratory minimum detection level of 0.0453 ppb (0.0816 $\mu g/m^3$) from samples on various days at sites #1, #4, #5, #6, #7 and #8. Overall, Site #3 also had the highest post-control average concentration over the 7 days of sampling at 0.551 ppb (0.993 $\mu g/m^3$), followed by Site #2 at 0.430 ppb (0.774 $\mu g/m^3$). Substituting one-half of the laboratory minimum detection level as a conservative estimate for non-detected results, site #5 had the lowest post-control average concentration at 0.140 ppb (0.251 $\mu g/m^3$). Table 6 provides a full listing of the post-control sampling results. Figure 8 provides a chart of the post-control sampling data, organized by site.

For the post-control background samples, all collected at the APCD's LaCasa site had concentrations that were below the laboratory minimum detection level of 0.0453 ppb (0.0816 $\mu g/m^3$). In contrast, all the background samples at the APCD's NREL site were above the detection level, with a maximum of 0.580 ppb (1.045 $\mu g/m^3$). The APCD Welch site had one sample above the minimum detection level and the APCD Arvada site had two samples above the minimum detection level. Substituting one-half the laboratory minimum detection level as a conservative estimate for non-detected results, the overall average background concentration for all four sites combined was 0.140 ppb (0.253 $\mu g/m^3$). Table 7 provides a full listing of the post-control sampling results. Figure 9 provides a chart of the post-control background sampling data, organized by site.

Following the sampling, information was received from the EPA that there could be a possible issue with co-elution of trans-2-butene with ethylene oxide in the gas chromatograph analyses performed by ERG. This was subsequently confirmed by ERG who indicated that pre-control sample analyses may be affected by this issue. ERG has indicated that trans-2-butene has only been detected in 40% of all samples they have analyzed nationwide in 2018, with an average of approximately 0.06 ppb (0.14 $\mu g/m^3$). From APCD sampling as part of an ozone precursor monitoring study at the Denver-CAMP and Platteville sites for August 2018, all samples were below the laboratory (Atmospheric Analysis & Consulting) detection levels of approximately 0.030 ppb (0.069 $\mu g/m^3$). Thus, any possible co-elution impact to the pre-control samples would be very small. All post-control sample analyses by ERG were

conducted using an additional ion in the mass spectrometry to resolve the issue and therefore were not affected.

IV. Conclusions

Overall, post-control sample values were significantly lower than the pre-control values, especially at the two sites, #2 and #3, that were closest to the Terumo BCT sterilization facility. This indicates that the additional emissions controls installed by Terumo BCT are having a significant impact. For the four sites used in both portions of the study, the post-control sample concentrations were on average 50-75% lower than the pre-control sample concentrations. Concentrations decreased with distance from the facility in both east and west directions, for both pre- and post-control portions of the study, as shown in Figure 10. The average background concentration from all four post-control sites is also shown. Many of the post-control samples were in the same general range as some of the background samples, especially for the sites further away in residential neighborhoods. It is unknown why there is such a detectable background concentration of ethylene oxide in the western portion of the Denver metro area. This may be a focus for further research.

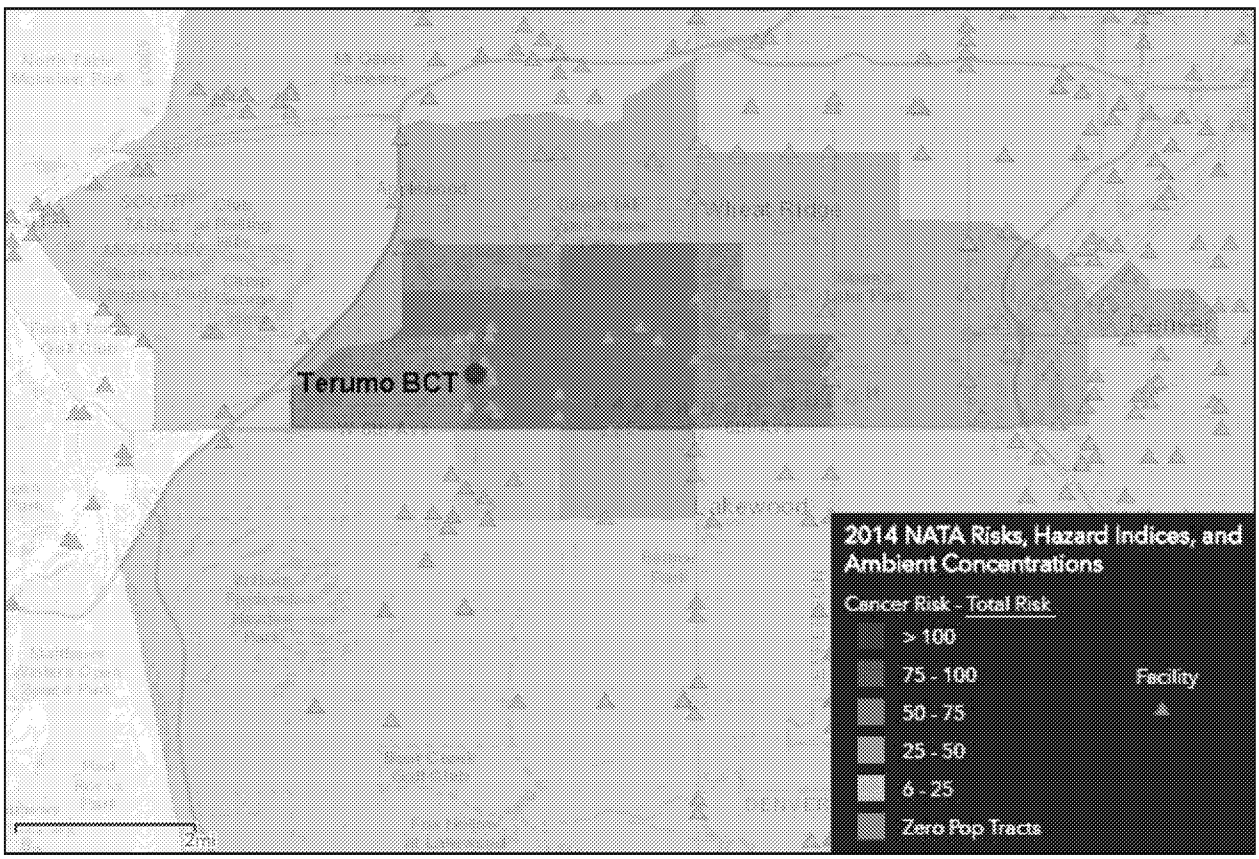

Figure 1. 2014 NATA – All possible facility sources and risks

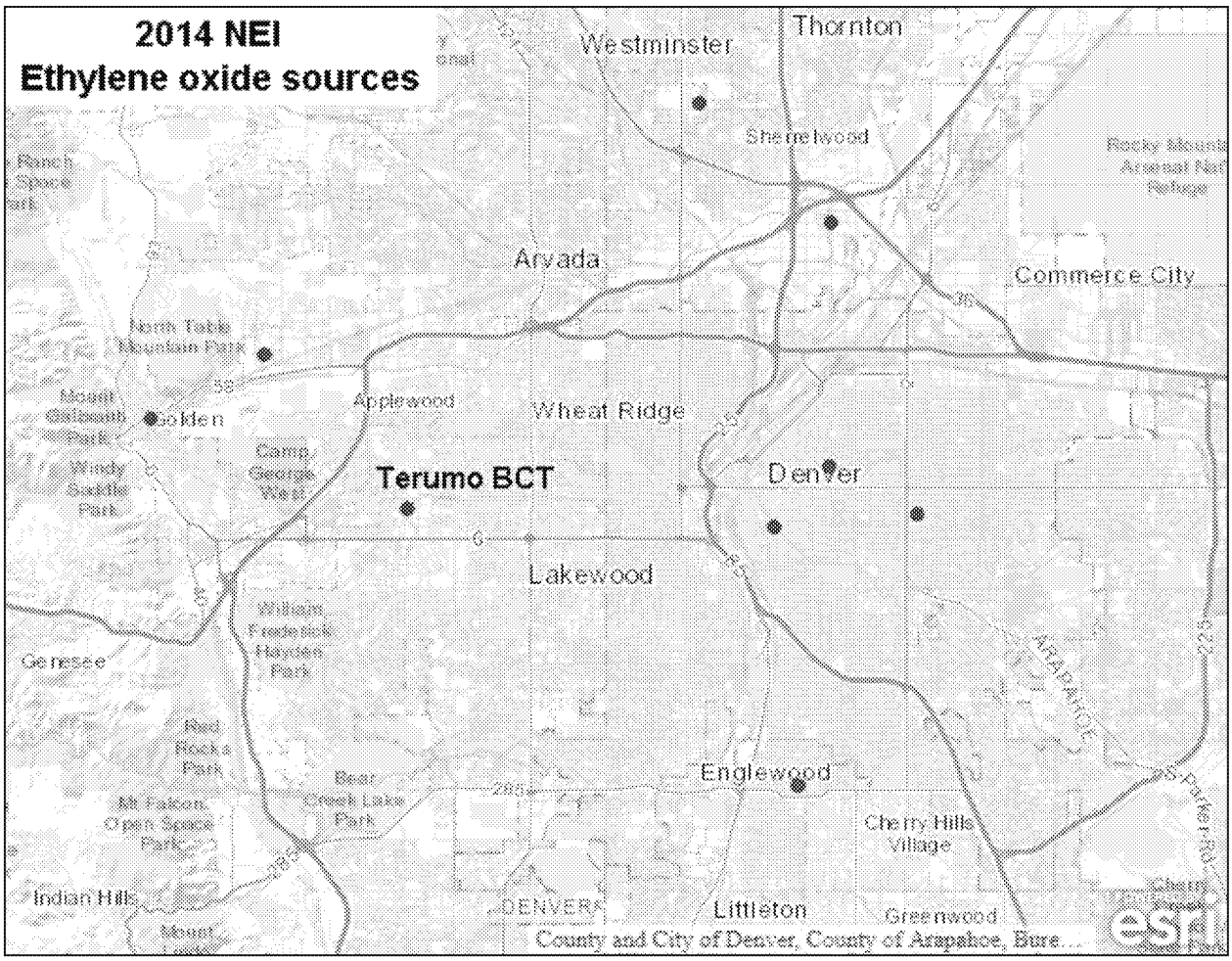

Figure 2. 2014 NEI for ethylene oxide sources

Table 1. 2014 NEI sources for ethylene oxide

FACILITY	ADDRESS	CITY	ZIP	EMISSIONS (lbs/year)
TERUMO BCT STERILIZATION SERVICES	11308 W COLLINS AVE	LAKEWOOD	80215	2220
COORSTEK, INC. - WEST TABLE MTN PLANT	4455 TABLE MOUNTAIN DR	GOLDEN	80403	329.222
ROCKY MOUNTAIN PRESTAIN, LLC	1570 E 66TH AVE	COMMERCE CITY	80229	164
U.S. VETERANS AFFAIRS MEDICAL CENTER	1055 CLERMONT ST	DENVER	80220	98
SWEDISH MEDICAL CENTER	501 E HAMPDEN AVE	ENGLEWOOD	80113	38.9
COORSTEK, INC. - 600 9TH ST	600 9TH ST	GOLDEN	80401	2.462
ST. ANTHONY HOSPITAL - NORTH	2551 W 84TH AVE	WESTMINSTER	80031	0
DENVER HEALTH & GENERAL HOSPITAL	777 BANNOCK ST	DENVER	80204	0
ST JOSEPH HOSPITAL	1835 FRANKLIN ST	DENVER	80218	0

Figure 3. Air sampling locations

Table 2. Air sampling location details

Site #	Direction from Terumo BCT vents	Distance from Terumo BCT vents	Notes
1	W	490 feet	West edge of McDonnell Park, on chainlink fence, approx. 4' above ground
2	W	130 feet	West side of light rail track, east side of Simms St., on chainlink fence, approx. 6' above ground
3	E	440 feet	East edge of Terumo BCT facility, on chainlink fence, approx. 6' above ground
4	ESE	1075 feet	On bridge railing over Lakewood Gulch, west side of Quail St., approx. 3' above ground
5	NW	1910 feet	Daniels Preschool, west side of Union St., on chainlink fence, approx. 6' above ground
6	ESE	2050 feet	Lakewood Gulch, west of Oak St., on chainlink fence, approx. 6' above ground
7	ESE	3075 feet	Sunset Park, east of Oak St., on wood splitrail fence approx. 3' above ground
8	ESE	5160 feet	On church solar panel chainlink fence, east side of Kipling St., approx. 6' above ground

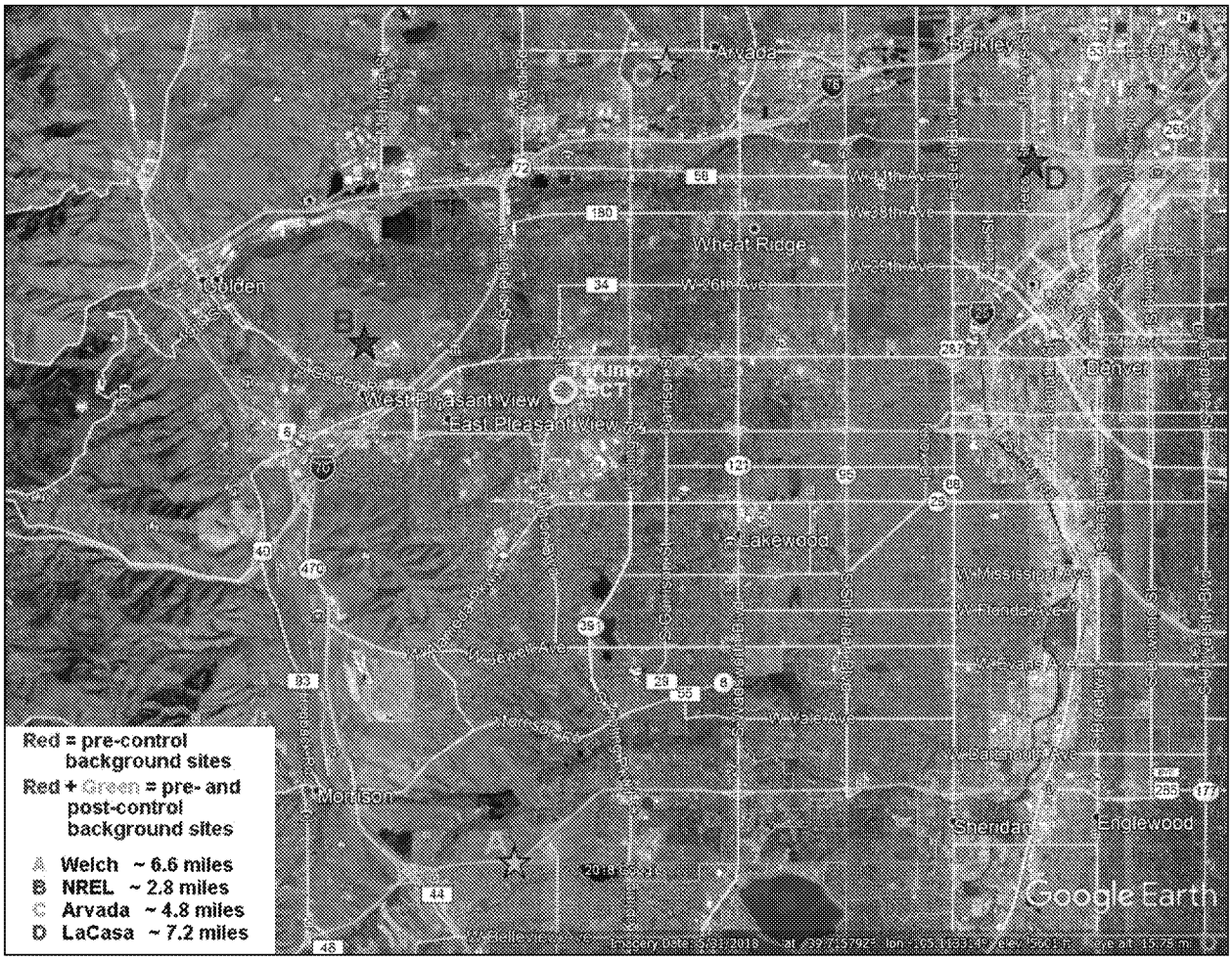

Figure 4. Background sampling locations

Table 3. Background sampling location details

Site	Direction from Terumo BCT vents	Distance from Terumo BCT vents	Notes
Welch Background	SSW	6.6 miles	CDPHE "Welch" air monitoring site, 12400 W. US Hwy. 285, Morrison
NREL Background	WNW	2.8 miles	CDPHE "NREL" air monitoring site, 2054 Quaker St., Golden
Arvada Background	NNE	4.8 miles	CDPHE "Arvada" air monitoring site, 9101 W. 57th Ave., Arvada
La Casa Background	NE	7.2 miles	CDPHE "LaCasa" air monitoring site, 4545 Navajo St., Denver

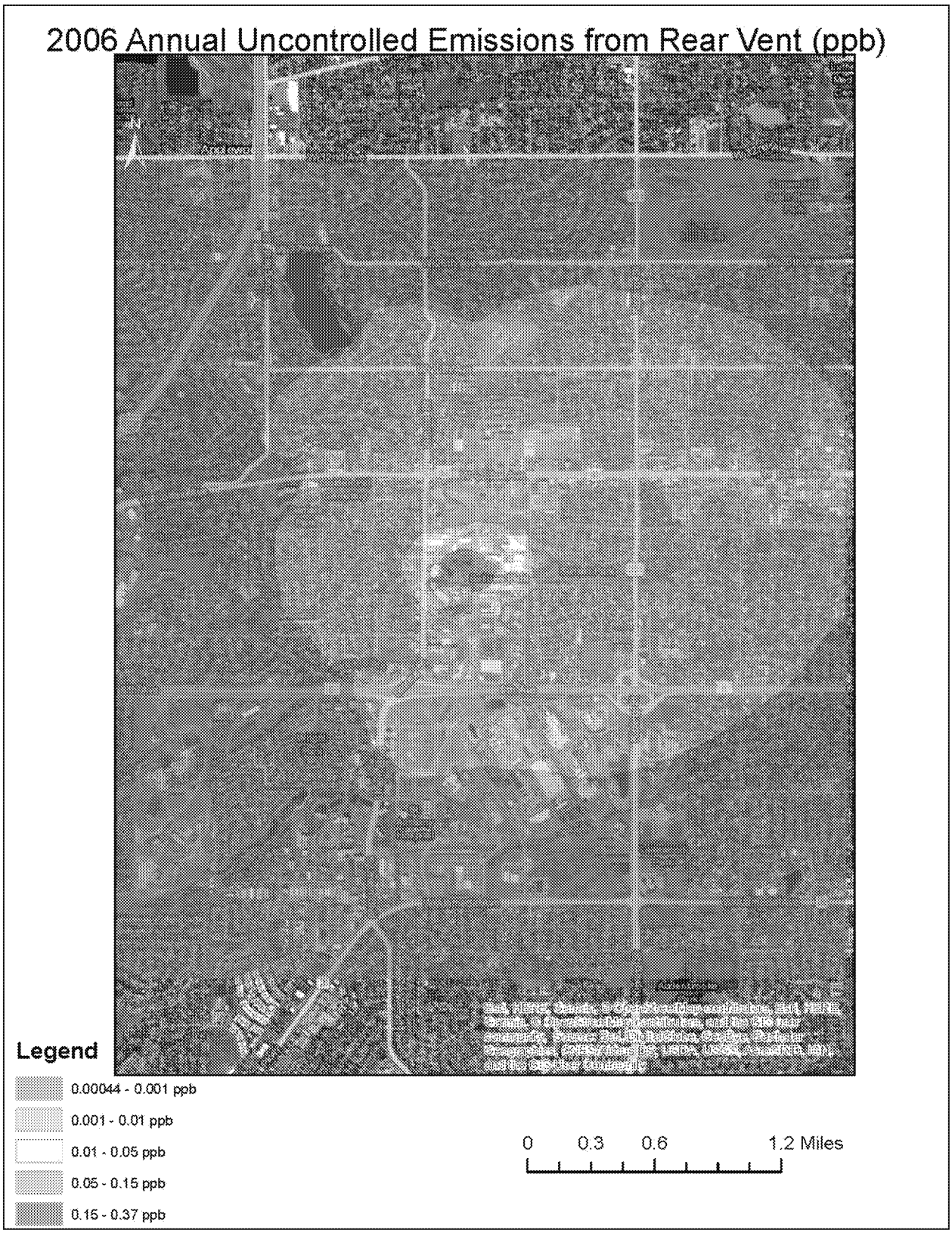

Figure 5. AERMOD results for pre-control emissions

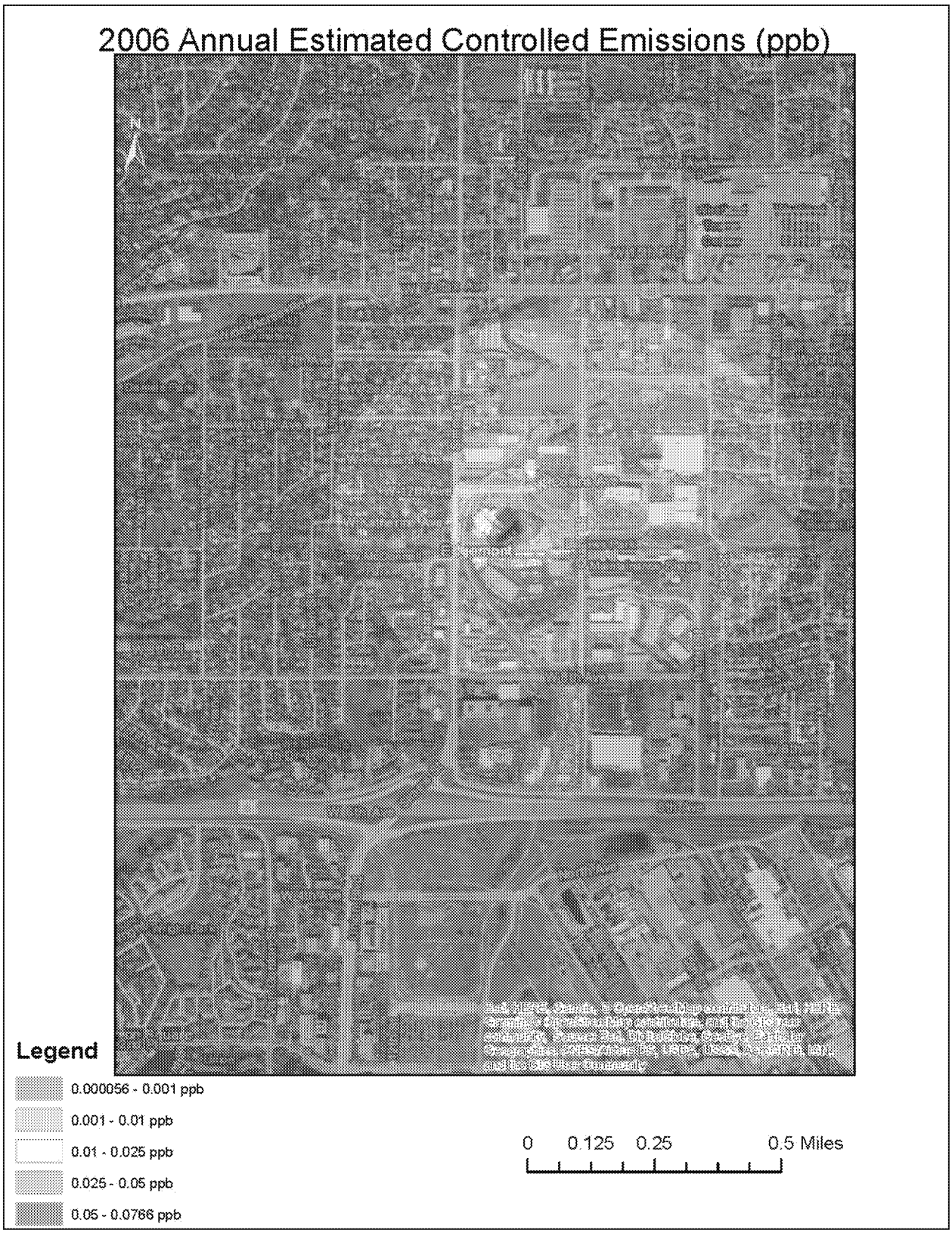

Figure 6. AERMOD results for estimated post-control emissions

Table 4. Pre-control ethylene oxide sampling results

Site #	Start Date	Start Time	End Date	End Time	Minutes	Concentration (ppb)	Concentration (µg/m³)
1	8/24/2018	8:52	8/25/2018	8:02	1390	1.010	1.820
1	8/25/2018	8:08	8/26/2018	7:52	1424	0.394	0.710
1	8/26/2018	7:57	8/27/2018	7:32	1415	0.557	1.004
1	8/27/2018	7:40	8/28/2018	8:00	1460	0.170	0.306
1	8/28/2018	8:05	8/29/2018	7:48	1423	0.280	0.504
1	8/29/2018	7:53	8/30/2018	8:03	1450	0.622	1.121
1	8/30/2018	8:07	8/31/2018	7:59	1432	0.263	0.474
1	***Average***					***0.471***	***0.848***
2	8/24/2018	8:42	8/25/2018	8:17	1415	3.570	6.432
2	8/25/2018	8:23	8/26/2018	8:06	1423	0.855	1.540
2	8/26/2018	8:10	8/27/2018	7:46	1404	1.820	3.279
2	8/27/2018	7:49	8/28/2018	8:15	1466	0.269	0.485
2	8/28/2018	8:21	8/29/2018	8:01	1420	0.887	1.598
2	8/29/2018	8:06	8/30/2018	8:15	1449	3.090	5.567
2	8/30/2018	8:17	8/31/2018	8:07	1430	1.150	2.072
2	***Average***					***1.663***	***2.996***
3	8/24/2018	8:27	8/25/2018	8:31	1444	2.390	4.306
3	8/25/2018	8:36	8/26/2018	8:20	1424	1.490	2.684
3	8/26/2018	8:30	8/27/2018	7:58	1408	1.870	3.369
3	8/27/2018	8:02	8/28/2018	8:30	1468	2.510	4.522
3	8/28/2018	8:35	8/29/2018	8:18	1423	1.270	2.288
3	8/29/2018	8:23	8/30/2018	8:25	1442	0.965	1.739
3	8/30/2018	8:28	8/31/2018	8:18	1430	1.520	2.739
3	***Average***					***1.716***	***3.092***
4	8/24/2018	8:10	8/25/2018	8:42	1472	0.677	1.220
4	8/25/2018	8:49	8/26/2018	8:38	1429	0.564	1.016
4	8/26/2018	8:44	8/27/2018	8:09	1405	0.497	0.895
4	8/27/2018	8:13	8/28/2018	8:41	1458	1.060	1.910
4	8/28/2018	8:45	8/29/2018	8:31	1426	0.758	1.366
4	8/29/2018	8:36	8/30/2018	8:37	1441	0.670	1.207
4	8/30/2018	8:40	8/31/2018	8:30	1430	0.784	1.412
4	***Average***					***0.716***	***1.289***

Table 5. Pre-control background ethylene oxide sampling results

Site	Start Date	Start Time	End Date	End Time	Minutes	Concentration (ppb)	Concentration (ug/m3)
NREL	9/9/2018	7:35	9/10/2018	8:00	1465	<0.0453	<0.0816
La Casa	9/9/2018	8:15	9/10/2018	8:40	1465	0.167	0.301
***Background average** (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)*						***0.095***	***0.171***

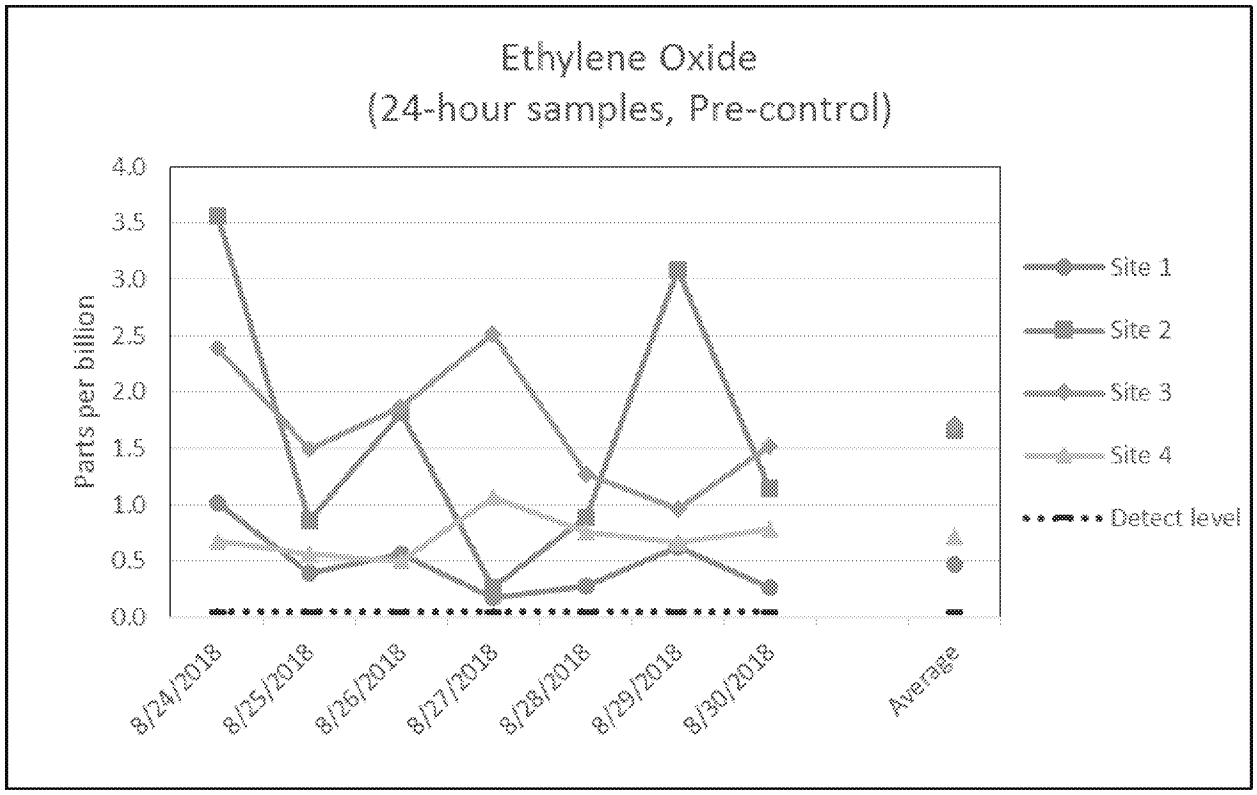

Figure 7. Pre-control ethylene oxide sampling results by site

Table 6. Post-control ethylene oxide sampling results

Site #	Start Date	Start Time	End Date	End Time	Minutes	Concentration (ppb)	Concentration (µg/m³)
1	10/17/2018	8:07	10/18/2018	8:08	1441	<0.0453	<0.0816
1	10/18/2018	8:15	10/19/2018	6:48	1353	0.125	0.225
1	10/19/2018	7:00	10/20/2018	6:55	1435	0.240	0.432
1	10/20/2018	7:00	10/21/2018	6:35	1415	0.452	0.814
1	10/21/2018	6:45	10/22/2018	6:45	1440	0.236	0.425
1	10/22/2018	6:55	10/23/2018	7:05	1450	0.231	0.416
1	10/23/2018	7:13	10/24/2018	6:41	1408	0.326	0.587
1	***Average (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)***					***0.233***	***0.420***
2	10/17/2018	8:22	10/18/2018	8:24	1442	0.257	0.463
2	10/18/2018	8:35	10/19/2018	7:15	1360	0.188	0.339
2	10/19/2018	7:20	10/20/2018	7:15	1435	0.682	1.229
2	10/20/2018	7:15	10/21/2018	6:50	1415	0.709	1.277
2	10/21/2018	7:00	10/22/2018	7:00	1440	0.542	0.976
2	10/22/2018	7:05	10/23/2018	7:21	1456	0.186	0.335
2	10/23/2018	7:28	10/24/2018	6:47	1395	0.444	0.800
2	***Average (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)***					***0.430***	***0.774***
3	10/17/2018	8:42	10/18/2018	8:44	1442	0.198	0.357
3	10/18/2018	9:00	10/19/2018	7:30	1350	1.120	2.018
3	10/19/2018	7:40	10/20/2018	7:30	1430	0.686	1.236
3	10/20/2018	7:45	10/21/2018	7:05	1400	0.663	1.194
3	10/21/2018	7:15	10/22/2018	7:15	1440	0.329	0.593
3	10/22/2018	7:25	10/23/2018	7:37	1452	0.417	0.751
3	10/23/2018	7:45	10/24/2018	7:01	1396	0.446	0.804
3	***Average (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)***					***0.551***	***0.993***
4	10/17/2018	9:00	10/18/2018	9:09	1449	0.197	0.355
4	10/18/2018	9:15	10/19/2018	7:50	1355	0.513	0.924
4	10/19/2018	8:00	10/20/2018	7:45	1425	<0.0453	<0.0816
4	10/20/2018	7:55	10/21/2018	7:25	1410	0.287	0.517
4	10/21/2018	7:30	10/22/2018	7:30	1440	0.198	0.357
4	10/22/2018	7:35	10/23/2018	7:53	1458	0.228	0.411
4	10/23/2018	8:02	10/24/2018	7:12	1390	0.525	0.946
4	***Average (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)***					***0.282***	***0.507***

Site #	Start Date	Start Time	End Date	End Time	Minutes	Concentration (ppb)	Concentration (µg/m³)
5	10/17/2018	7:51	10/18/2018	7:50	1439	0.225	0.405
5	10/18/2018	7:55	10/19/2018	6:25	1350	<0.0453	<0.0816
5	10/19/2018	6:30	10/20/2018	6:30	1440	<0.0453	<0.0816
5	10/20/2018	6:45	10/21/2018	6:15	1410	0.240	0.432
5	10/21/2018	6:25	10/22/2018	6:25	1440	0.245	0.441
5	10/22/2018	6:40	10/23/2018	6:49	1449	<0.0453	<0.0816
5	10/23/2018	6:57	10/24/2018	6:32	1405	0.199	0.359
5	***Average** (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)*					***0.140***	***0.251***
6	10/17/2018	9:25	10/18/2018	9:27	1442	<0.0453	<0.0816
6	10/18/2018	9:30	10/19/2018	8:12	1362	0.204	0.368
6	10/19/2018	8:20	10/20/2018	8:10	1430	0.175	0.315
6	10/20/2018	8:20	10/21/2018	7:40	1400	0.259	0.467
6	10/21/2018	7:50	10/22/2018	7:50	1440	0.208	0.375
6	10/22/2018	8:00	10/23/2018	8:10	1450	0.305	0.550
6	10/23/2018	8:20	10/24/2018	7:35	1395	0.508	0.915
6	***Average** (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)*					***0.240***	***0.433***
7	10/17/2018	9:37	10/18/2018	9:44	1447	<0.0453	<0.0816
7	10/18/2018	9:50	10/19/2018	8:30	1360	0.148	0.267
7	10/19/2018	8:40	10/20/2018	8:25	1425	0.201	0.362
7	10/20/2018	8:50	10/21/2018	8:05	1395	0.269	0.485
7	10/21/2018	8:20	10/22/2018	8:10	1430	0.258	0.465
7	10/22/2018	8:20	10/23/2018	8:25	1445	<0.0453	<0.0816
7	10/23/2018	8:37	10/24/2018	7:47	1390	0.382	0.688
7	***Average** (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)*					***0.186***	***0.335***
8	10/17/2018	9:57	10/18/2018	10:05	1448	<0.0453	<0.0816
8	10/18/2018	10:15	10/19/2018	8:55	1360	0.088	0.159
8	10/19/2018	9:10	10/20/2018	8:45	1415	0.330	0.595
8	10/20/2018	8:55	10/21/2018	8:35	1410	0.318	0.573
8	10/21/2018	8:45	10/22/2018	8:30	1425	<0.0453	<0.0816
8	10/22/2018	8:45	10/23/2018	8:51	1446	<0.0453	<0.0816
8	10/23/2018	9:00	10/24/2018	8:10	1390	0.476	0.858
8	***Average** (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)*					***0.183***	***0.330***

Table 7. Post-control background ethylene oxide sampling results

Site #	Start Date	Start Time	End Date	End Time	Minutes	Concentration (ppb)	Concentration (ug/m3)
Welch	10/26/2018	6:35	10/27/2018	6:25	1430	0.200	0.360
Welch	10/27/2018	6:35	10/28/2018	6:30	1435	<0.0453	<0.0816
Welch	10/28/2018	6:40	10/29/2018	6:15	1415	<0.0453	<0.0816
Welch	10/29/2018	6:30	10/30/2018	6:10	1420	<0.0453	<0.0816
Welch	***Average** (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)*					***0.067***	***0.121***
NREL	10/26/2018	7:13	10/27/2018	7:00	1427	0.345	0.622
NREL	10/27/2018	7:10	10/28/2018	7:00	1430	0.580	1.045
NREL	10/28/2018	7:15	10/29/2018	6:50	1415	0.114	0.205
NREL	10/29/2018	7:00	10/30/2018	6:40	1420	0.169	0.304
NREL	***Average** (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)*					***0.302***	***0.544***
Arvada	10/26/2018	7:42	10/27/2018	7:40	1438	0.259	0.467
Arvada	10/27/2018	7:50	10/28/2018	7:40	1430	0.374	0.674
Arvada	10/28/2018	7:50	10/29/2018	7:30	1410	<0.0453	<0.0816
Arvada	10/29/2018	7:45	10/30/2018	7:30	1425	<0.0453	<0.0816
Arvada	***Average** (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)*					***0.170***	***0.306***
LaCasa	10/26/2018	8:10	10/27/2018	8:15	1445	<0.0453	<0.0816
LaCasa	10/27/2018	8:25	10/28/2018	8:10	1425	< 0.0453	<0.0816
LaCasa	10/28/2018	8:20	10/29/2018	8:00	1420	<0.0453	<0.0816
LaCasa	10/29/2018	8:15	10/30/2018	7:45	1410	<0.0453	<0.0816
LaCasa	***Average** (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)*					***0.023***	***0.041***
***Overall background average** (using ½ the lab minimum detection level of 0.0453 ppb or 0.0816 µg/m³ for non-detects)*						***0.140***	***0.253***

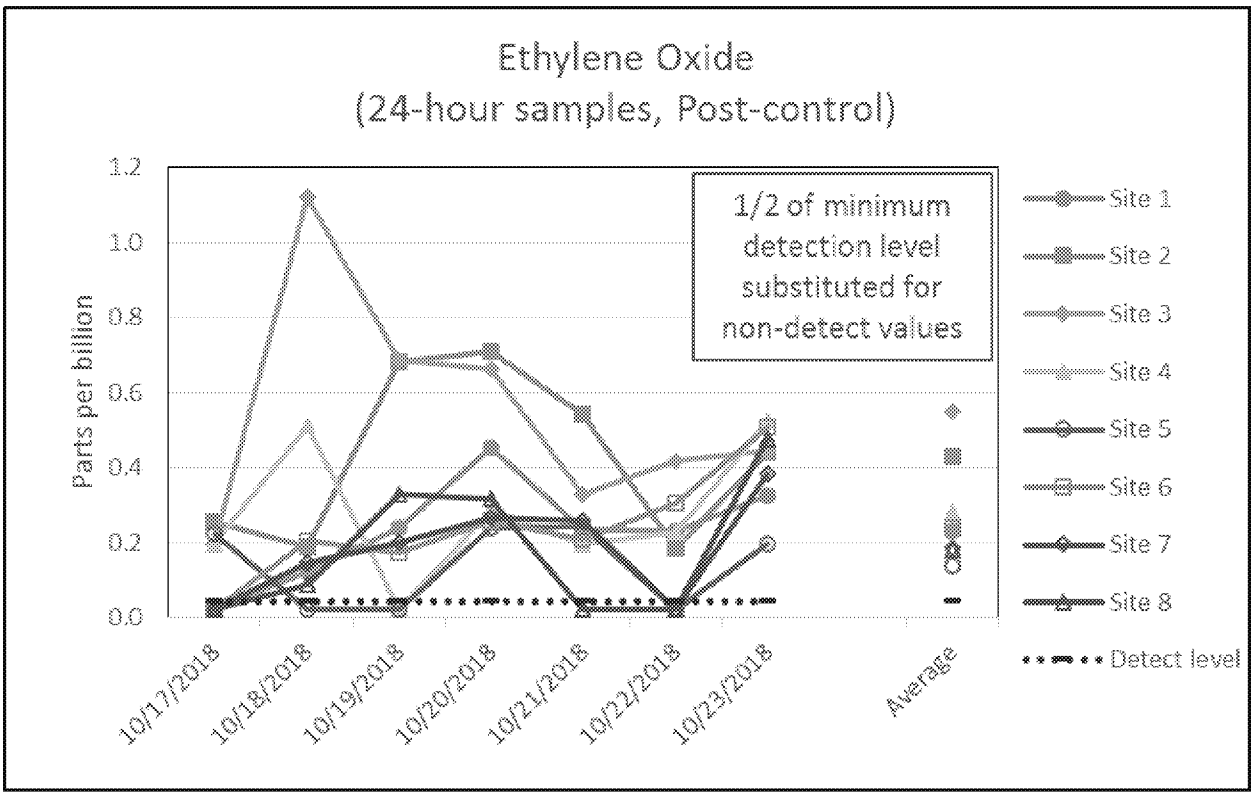

Figure 8. Post-control ethylene oxide sampling results by site

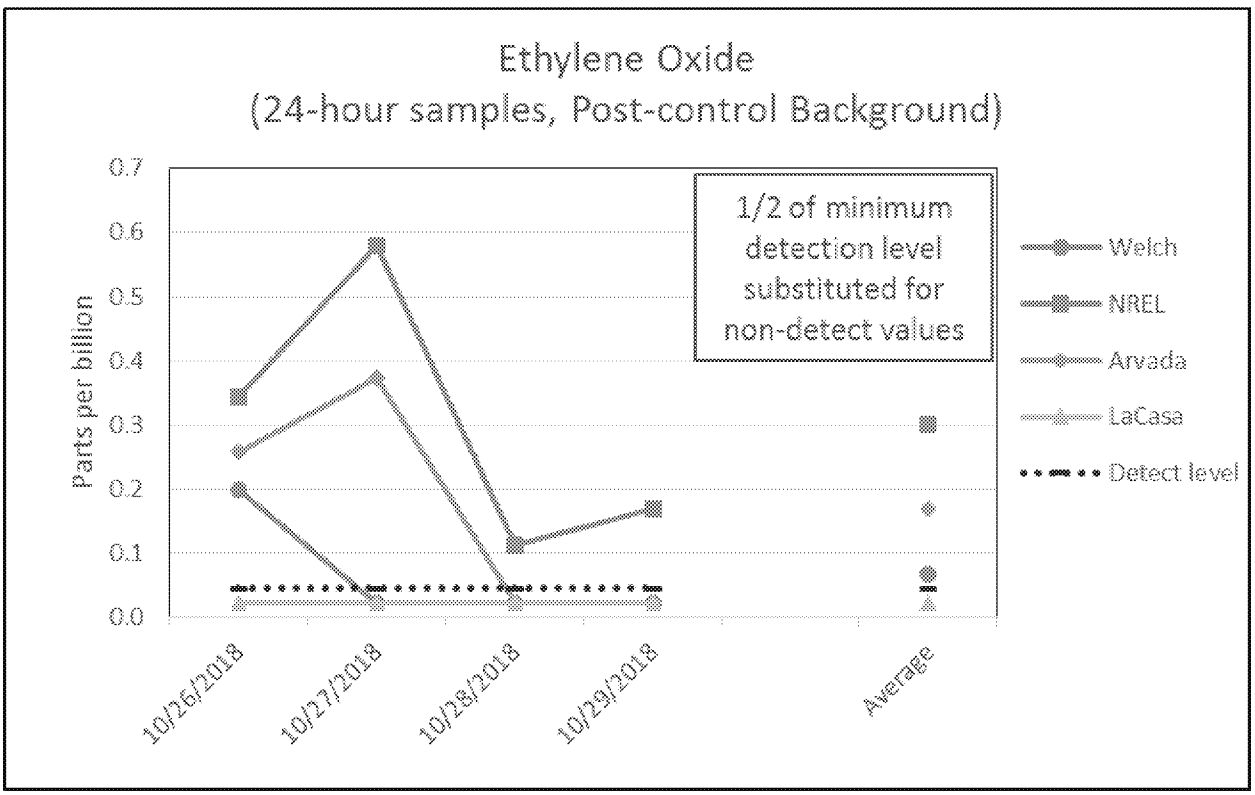

Figure 9. Post-control background ethylene oxide sampling results by site

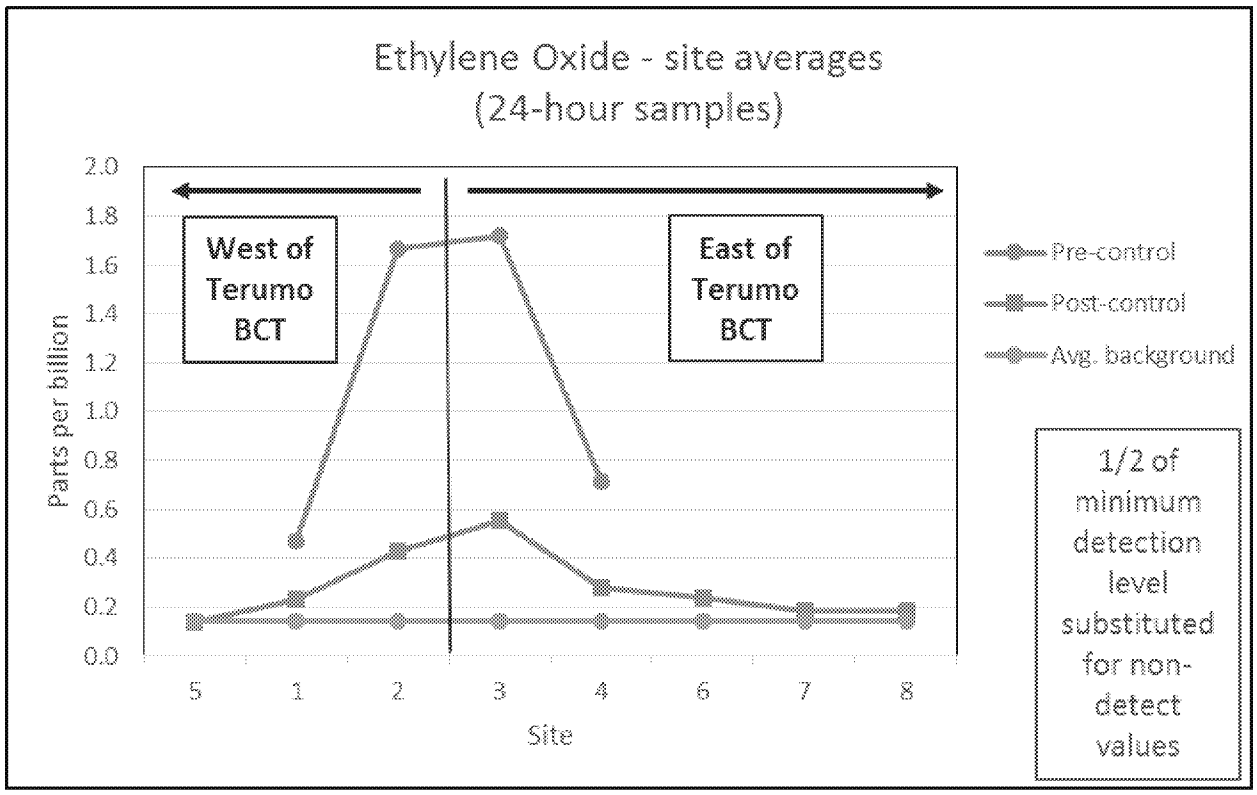

Figure 10. Pre and post sampling site averages, east and west of Terumo BCT

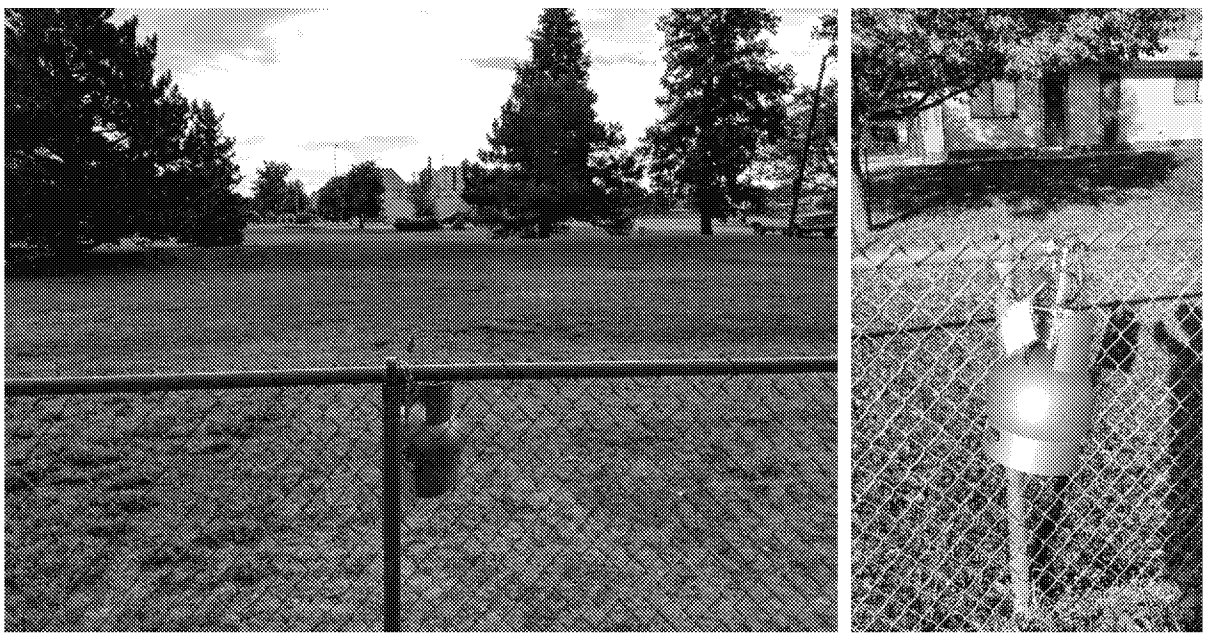
Figure 11. Site #1, looking towards Terumo BCT sterilization facility

Figure 12. Site #2, looking towards Terumo BCT sterilization facility


Figure 13. Site #3, looking towards Terumo BCT sterilization facility

Figure 14. Site #4, looking towards Terumo BCT sterilization facility

Figure 15. Site #5

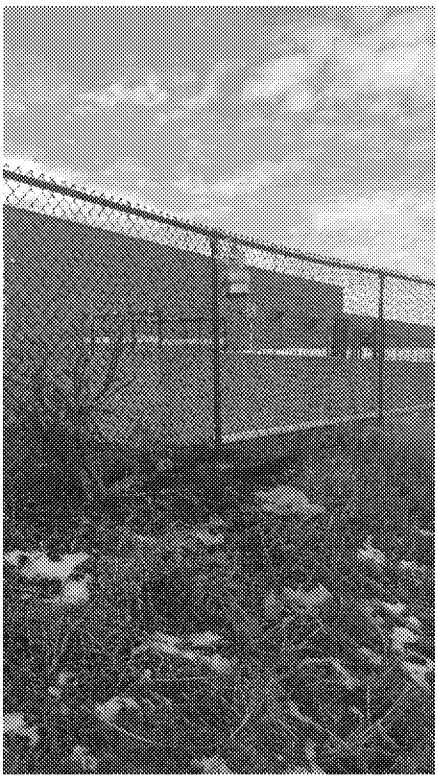

Figure 16. Site #6

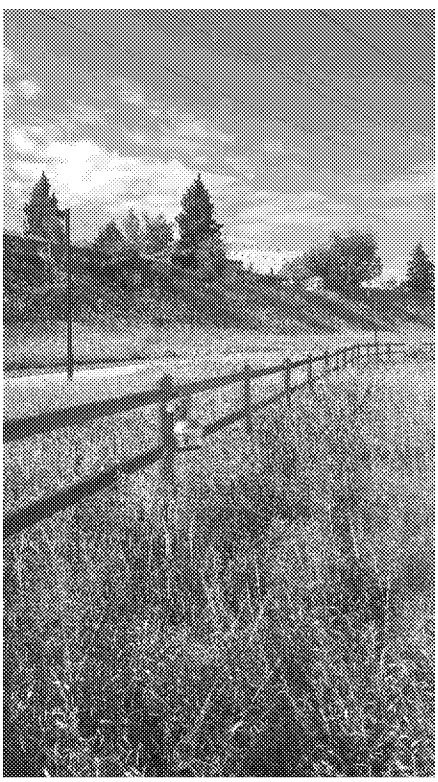

Figure 17. Site #7

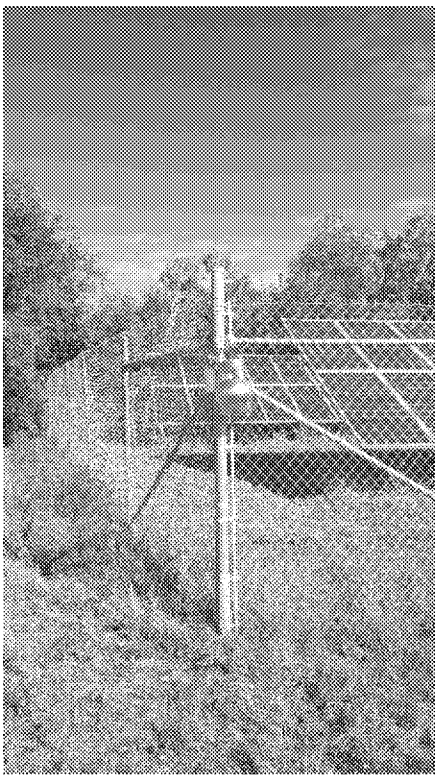

Figure 18. Site #8

Figure 19. Welch background site

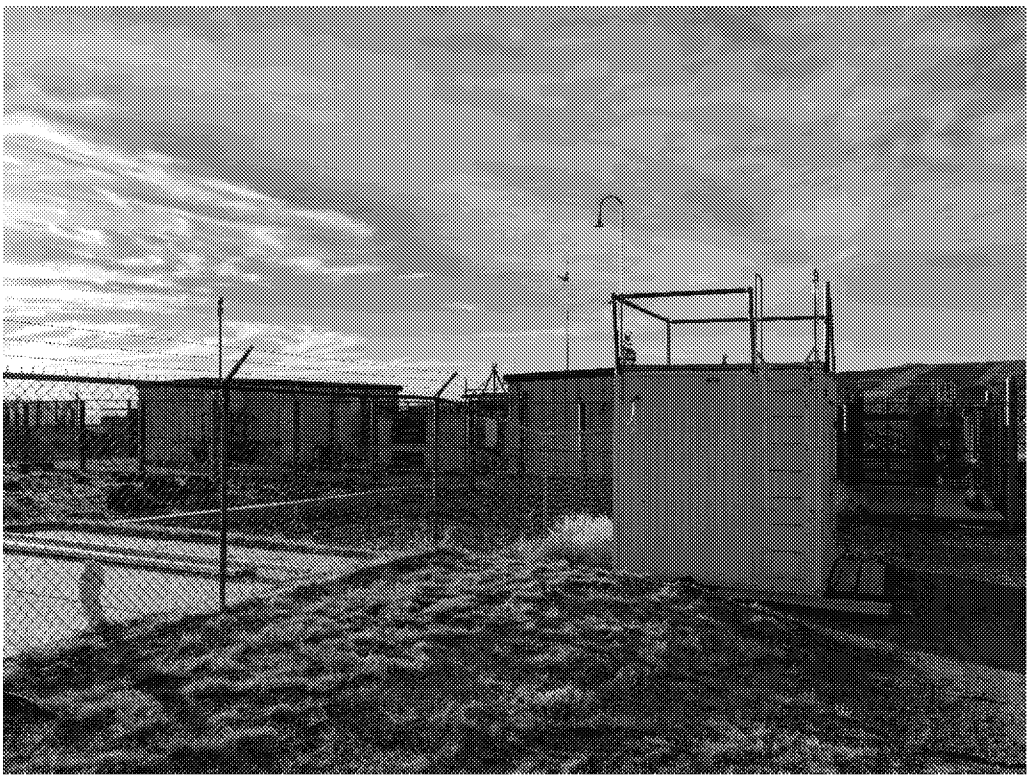

Figure 20. NREL background site

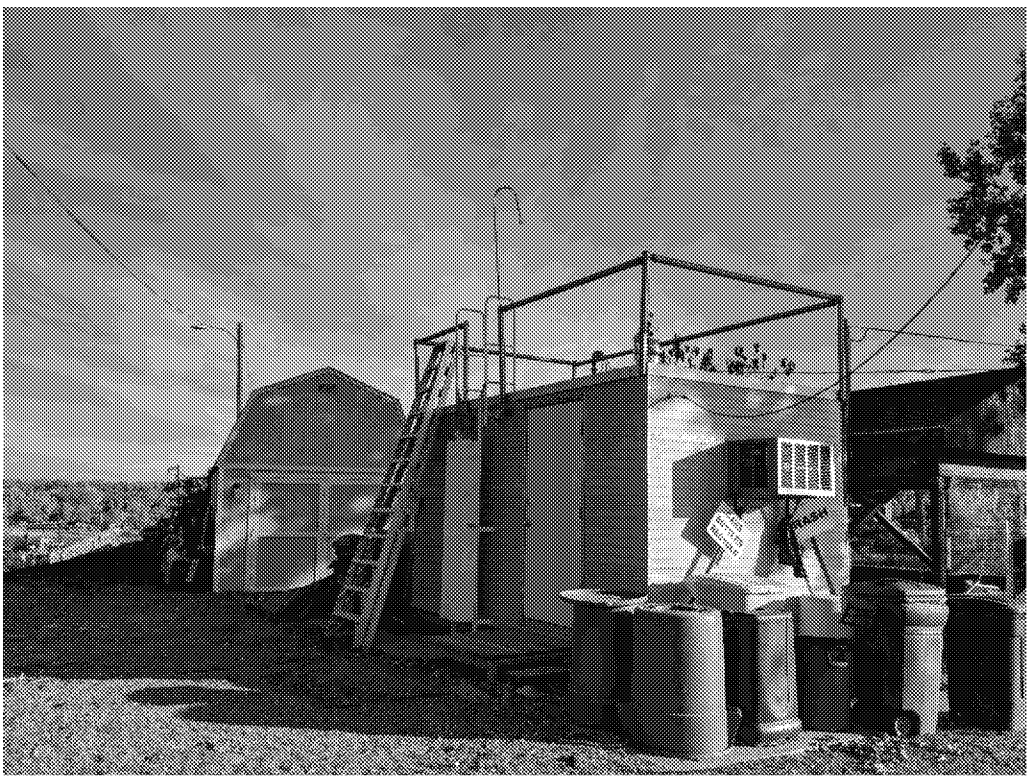

Figure 21. Arvada background site

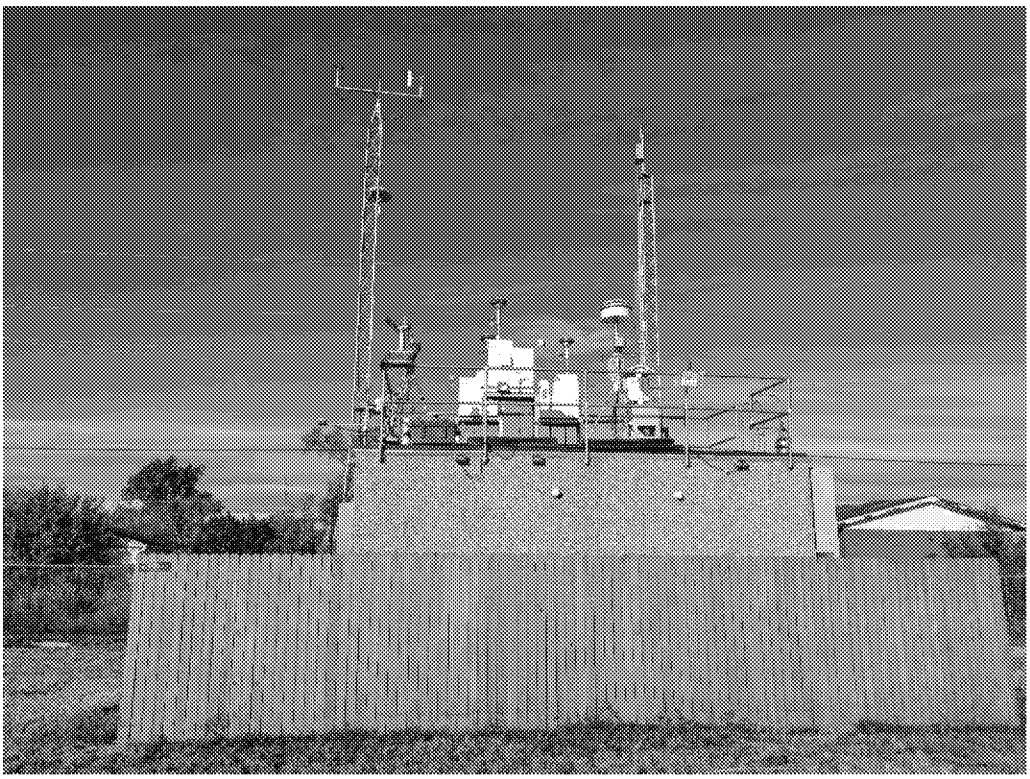

Figure 22. LaCasa background site